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Title: Skyrmion Spin Ice in Liquid Crystals

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Skyrmion Spin Ice in Liquid Crystals

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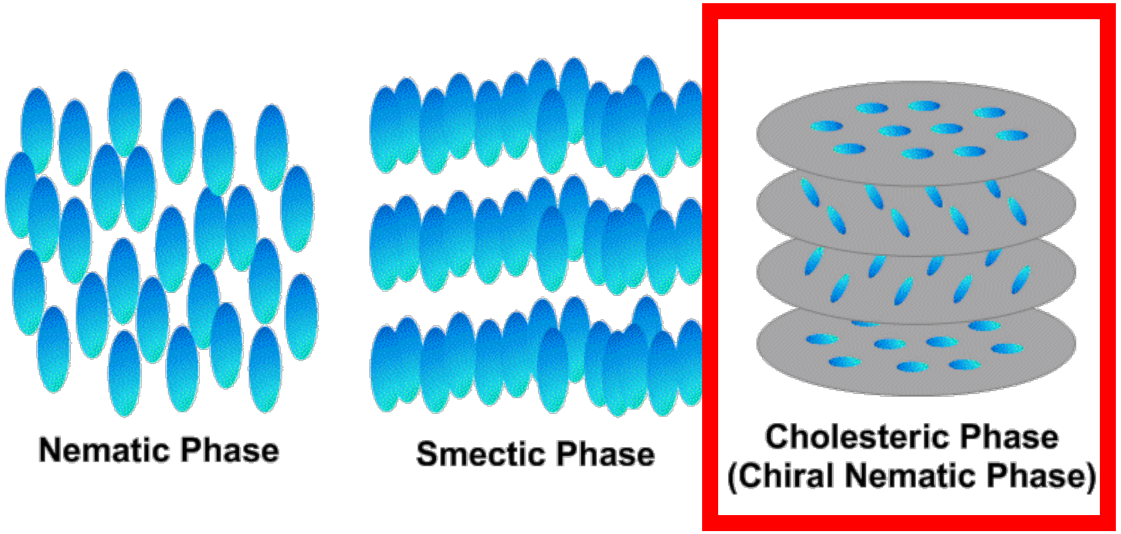
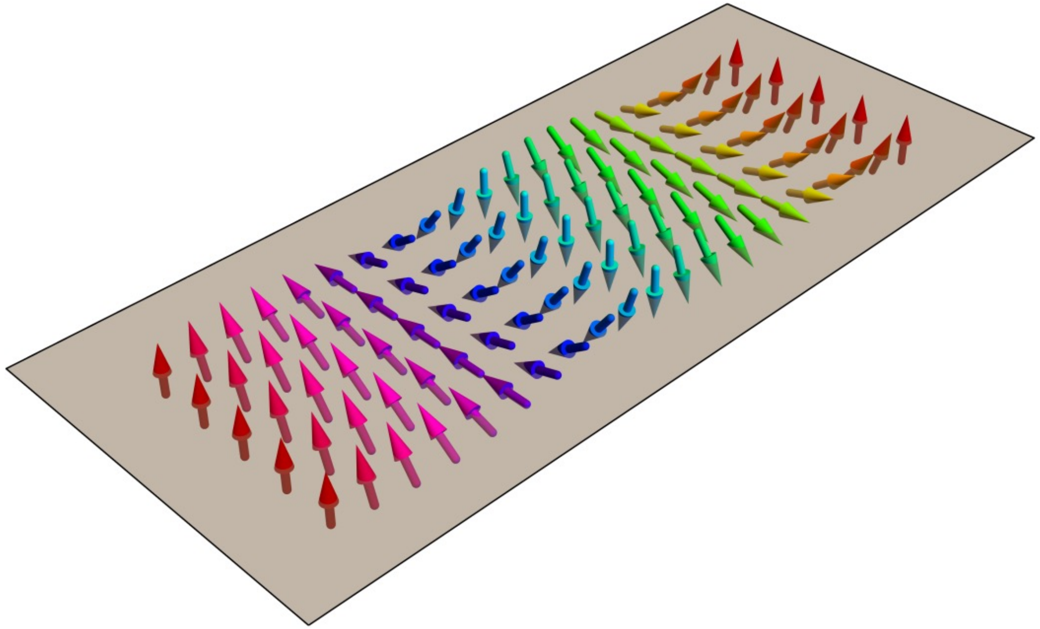
Los Alamos National Laboratory

Theoretical Division

Los Alamos NATIONAL LABORATORY

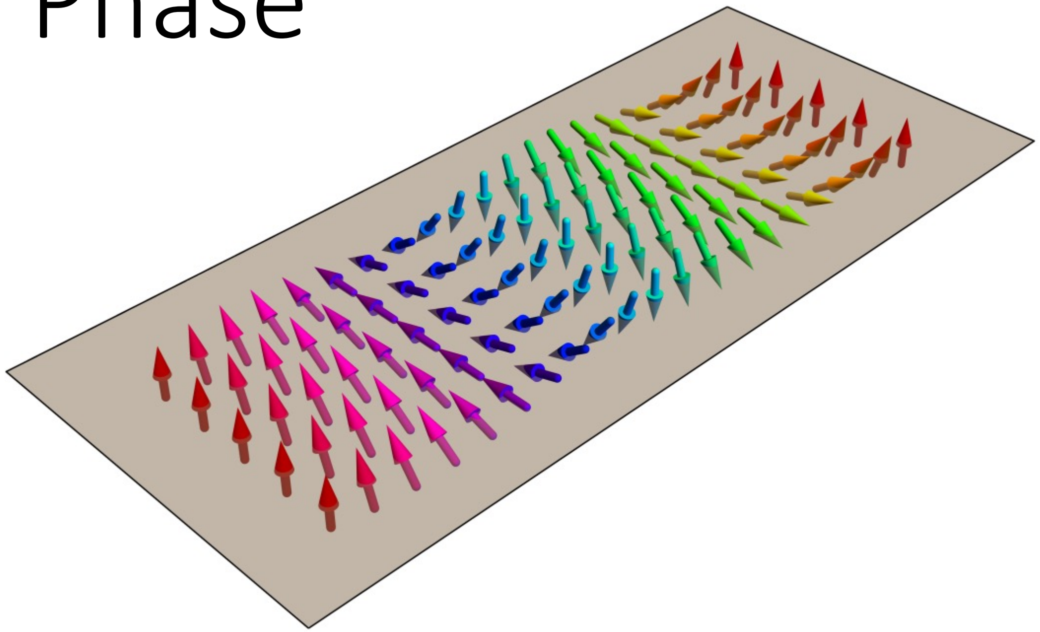
Various phases of Liquid Crystals



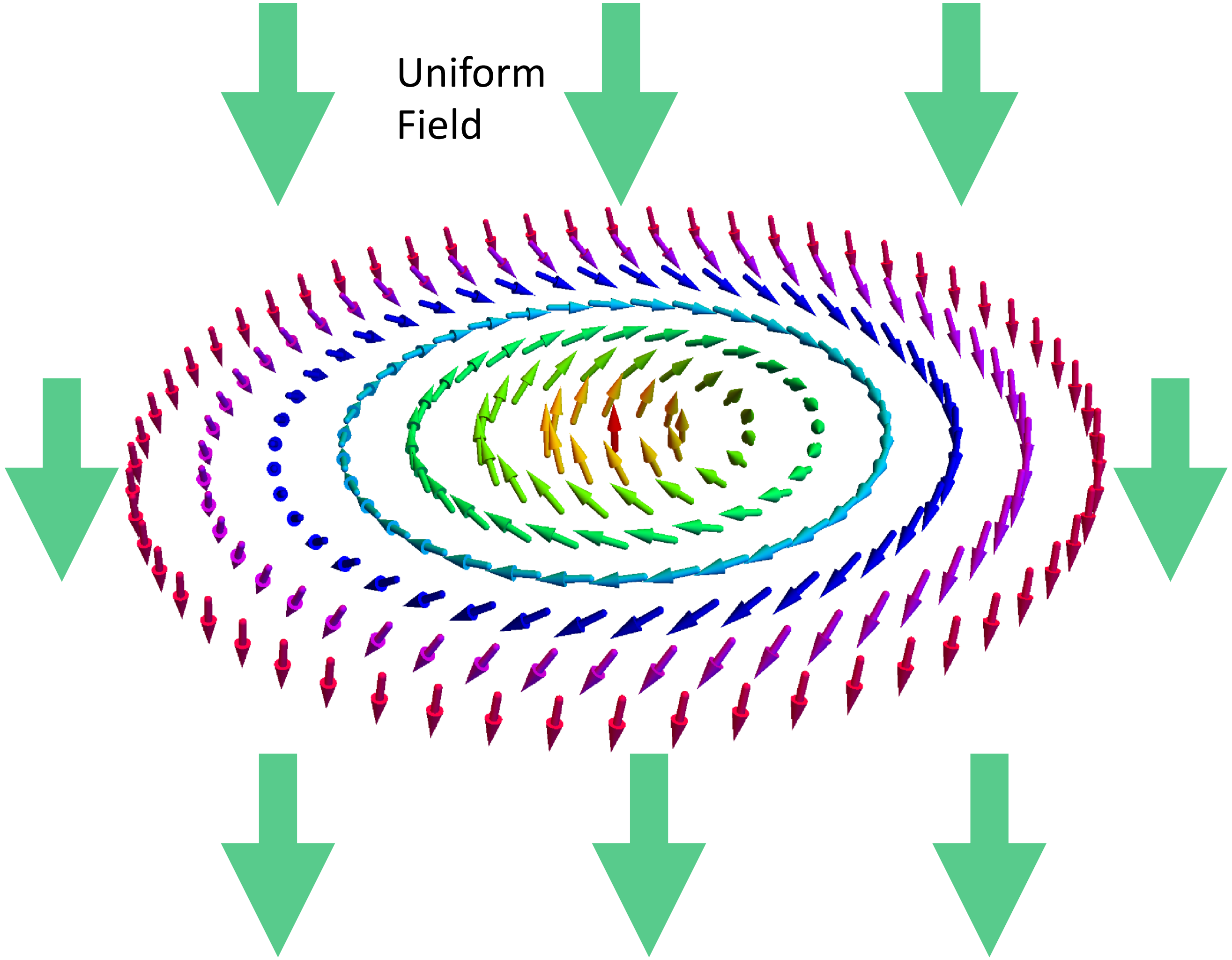


Skyrmion stabilized by homeotropic alignment

Cholesteric Phase

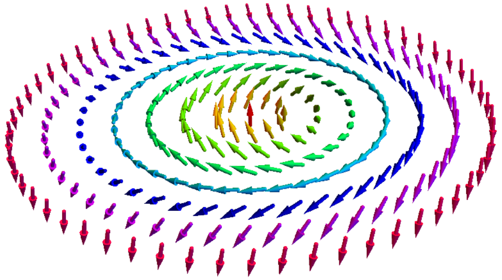


Liquid Crystal Skyrmion

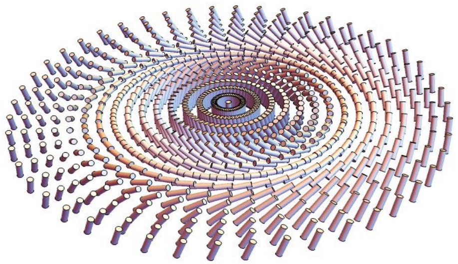


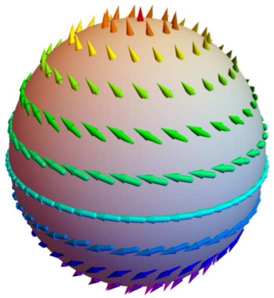
Liquid crystal skyrmions

Vectorized



LC

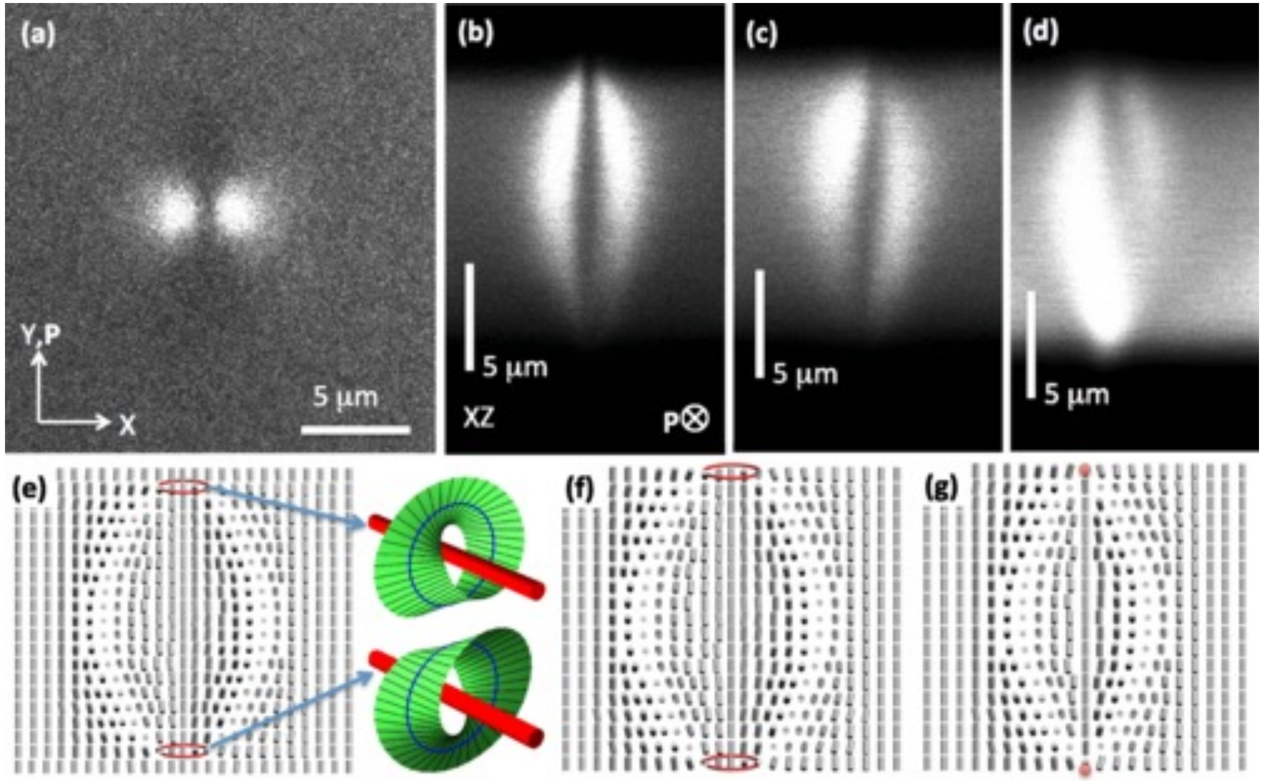




charge

Q=1

Experimental Realization



Ackerman et al.

Theoretical Model and simulations

$$F = \frac{1}{2}\,a\,Tr[Q^2] + \frac{1}{3}\,b\,Tr[Q^3] + \frac{1}{4}\,c\,Tr[Q^2]^2$$

a,b,c: Thermal coefficients

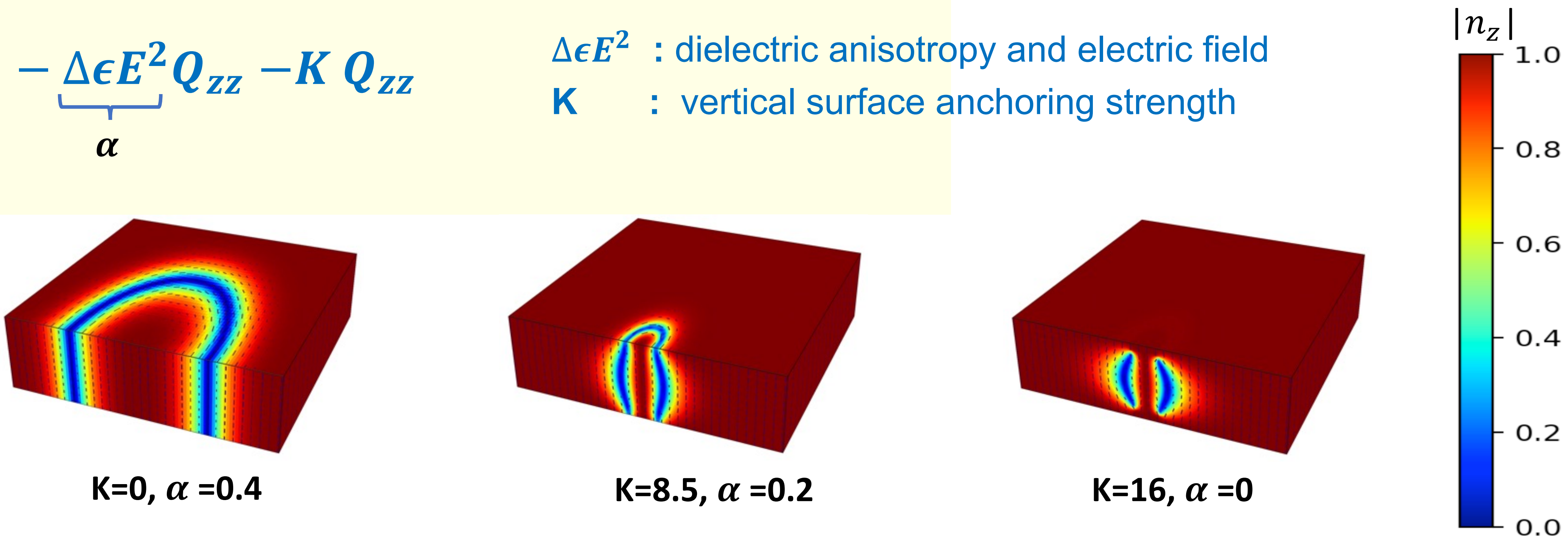
$$+\frac{1}{2}L(\partial_k Q_{ij})(\partial_k Q_{ij}) + 2q_0 L\epsilon_{lik}Q_{lj}\partial_k Q_{ij}$$

L: elastic constant q_0: natural twist

$$-\underbrace{\Delta\epsilon E^2}_{\alpha} Q_{zz} - K\,Q_{zz}$$

$\Delta\epsilon E^2$: dielectric anisotropy and electric field

K : vertical surface anchoring strength

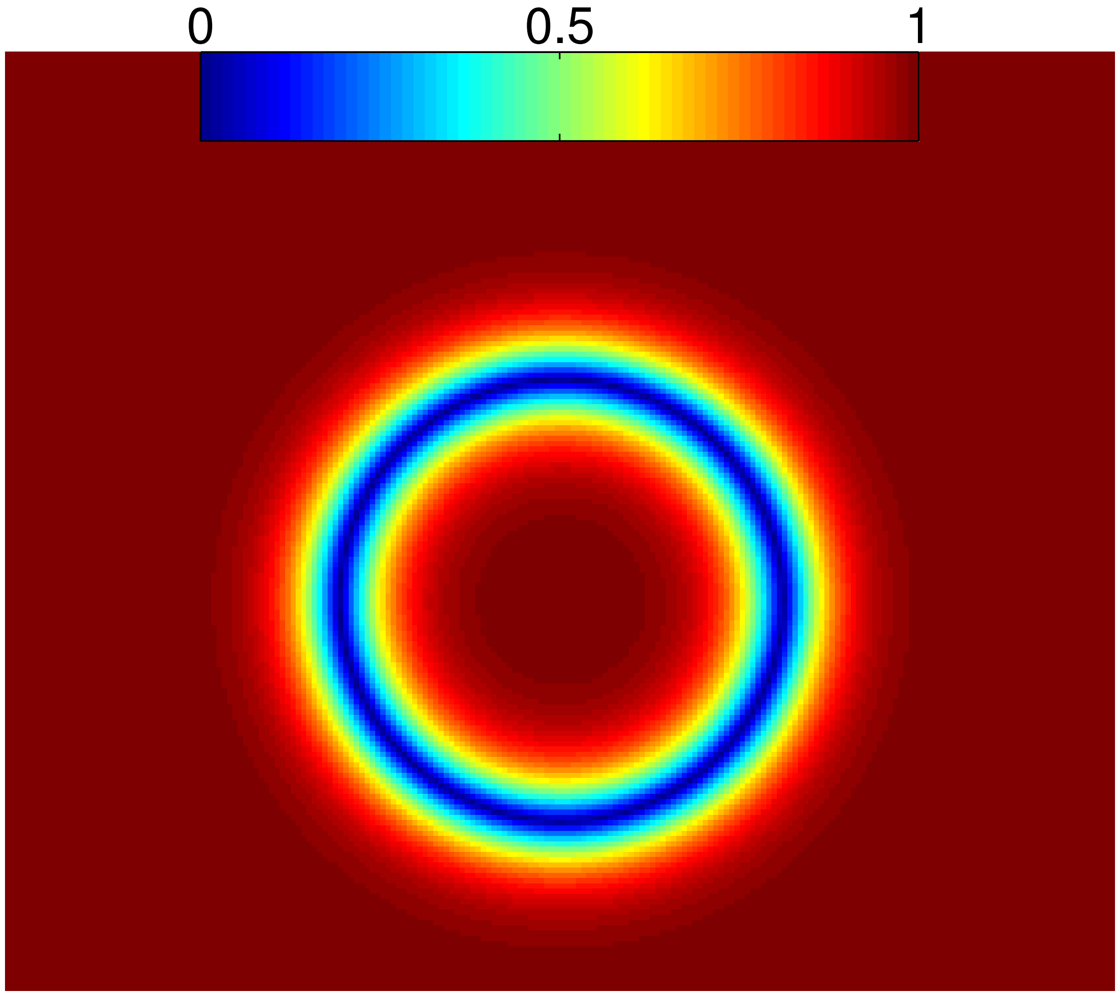


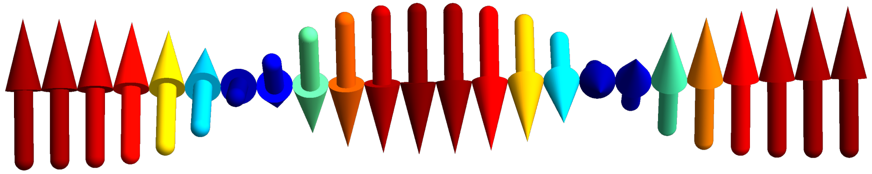
K=0, α =0.4

K=8.5, α =0.2

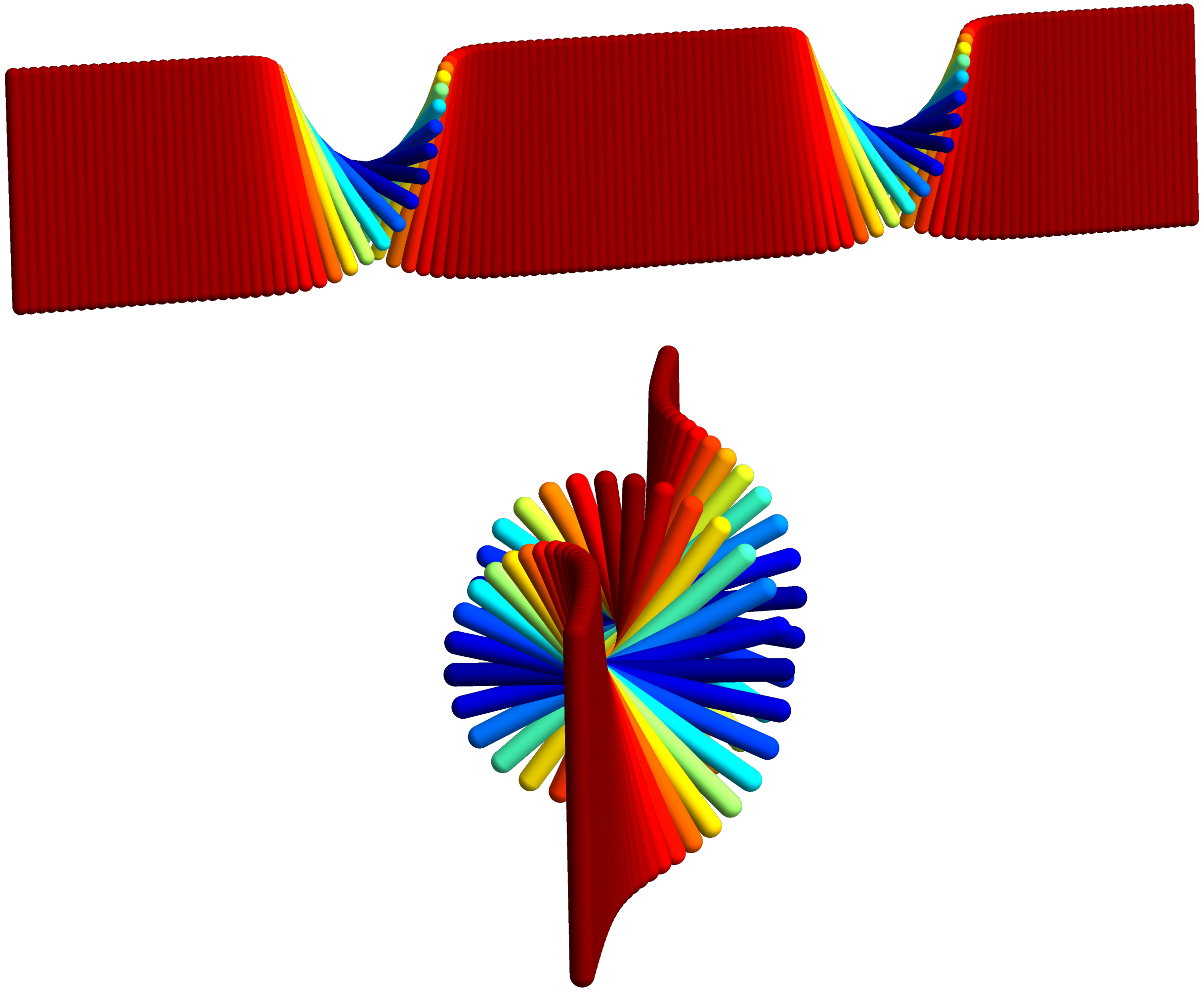
K=16, α =0

2D skyrmion

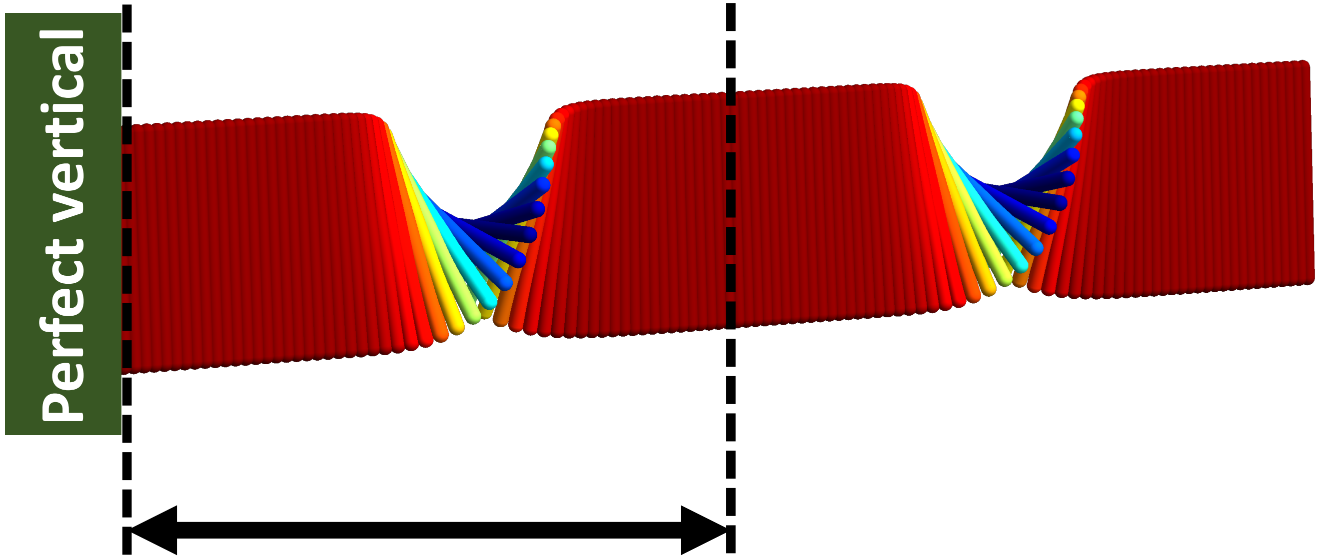




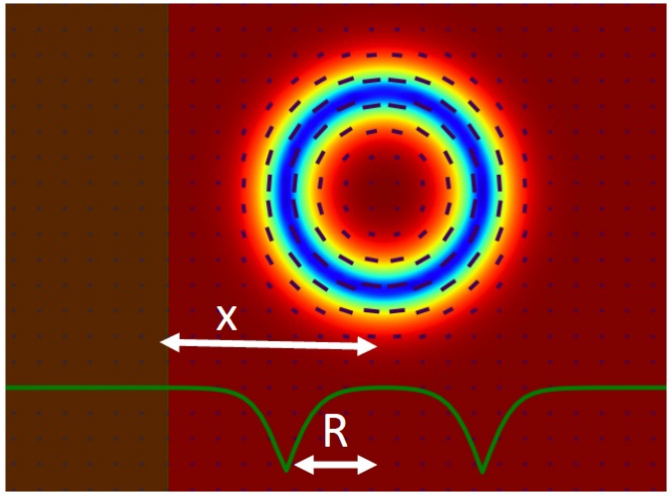
Director profile along diameter

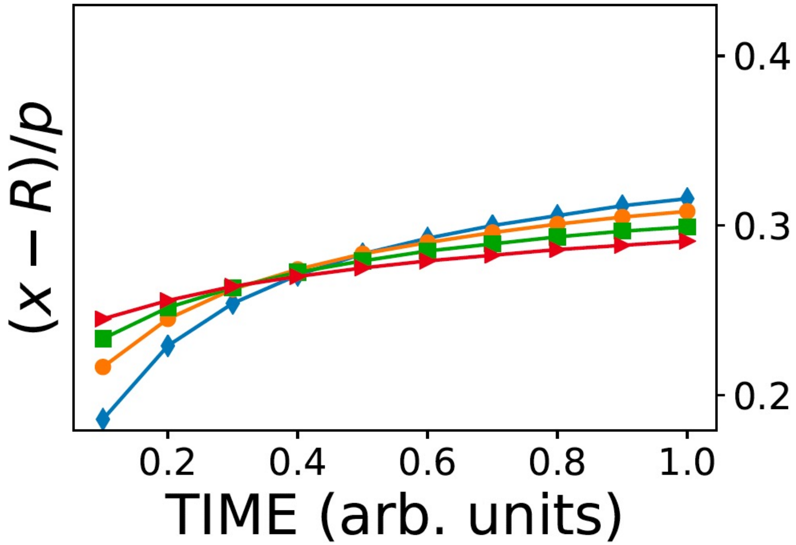


Walls produced by strong alignment

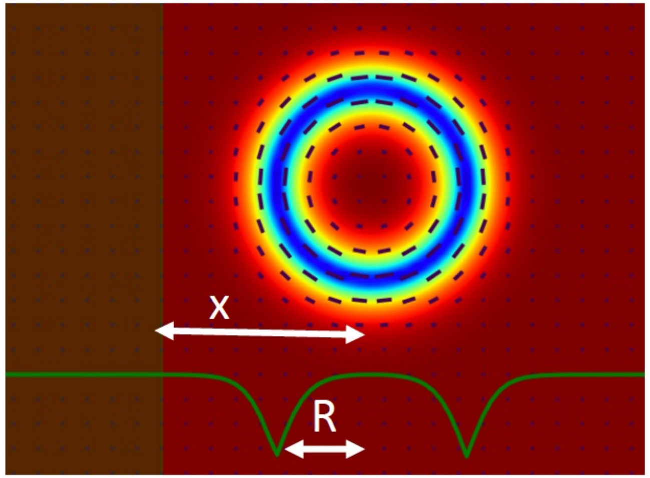


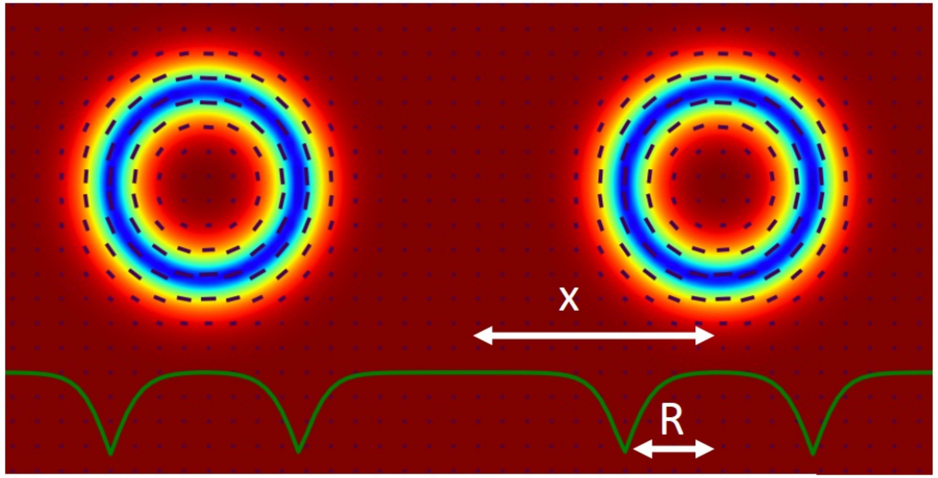
Characteristic
Relaxation length
180^{o} rotation

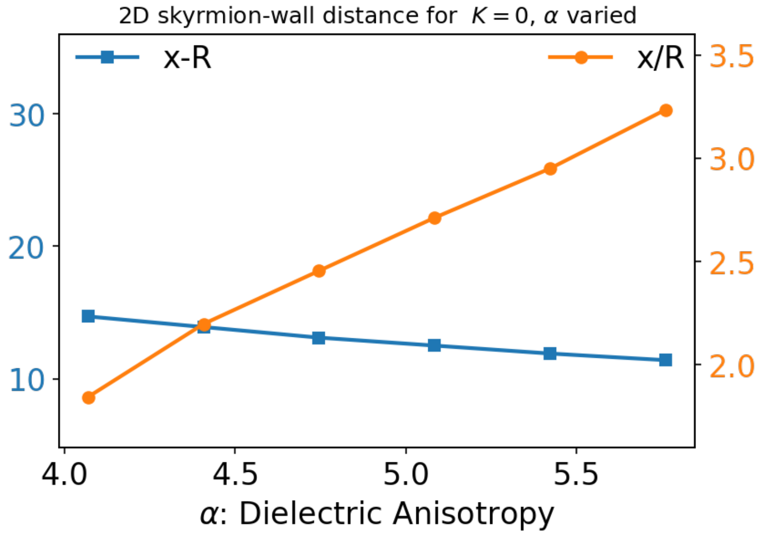


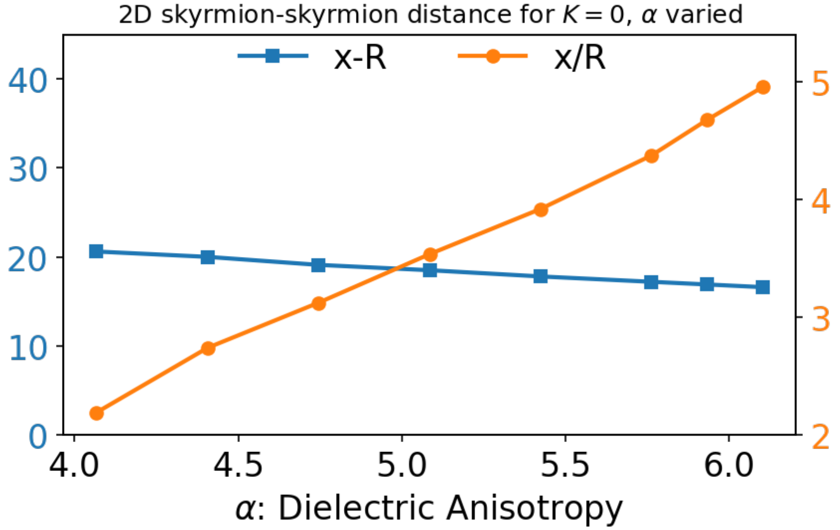


Skyrmion-skyrmion and skyrmion-wall distance

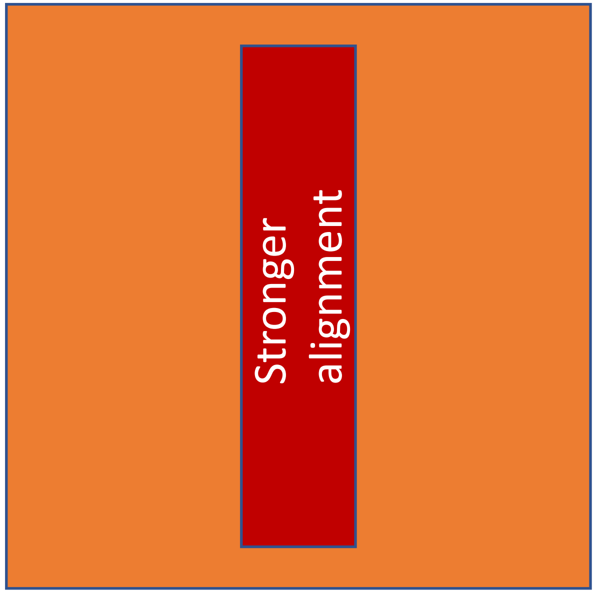


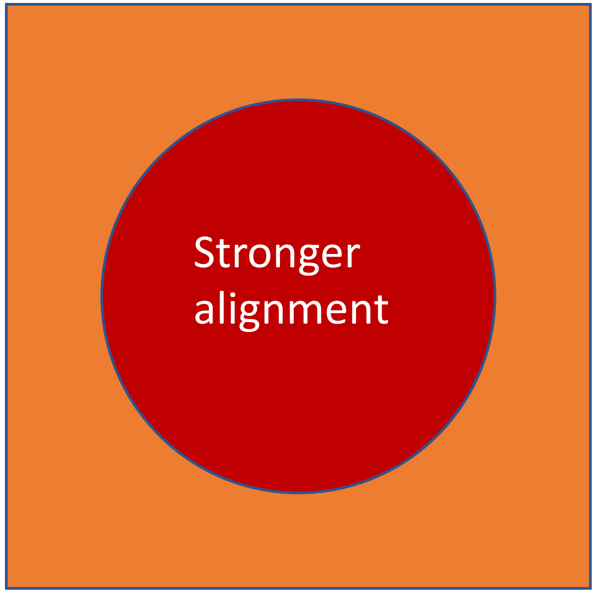


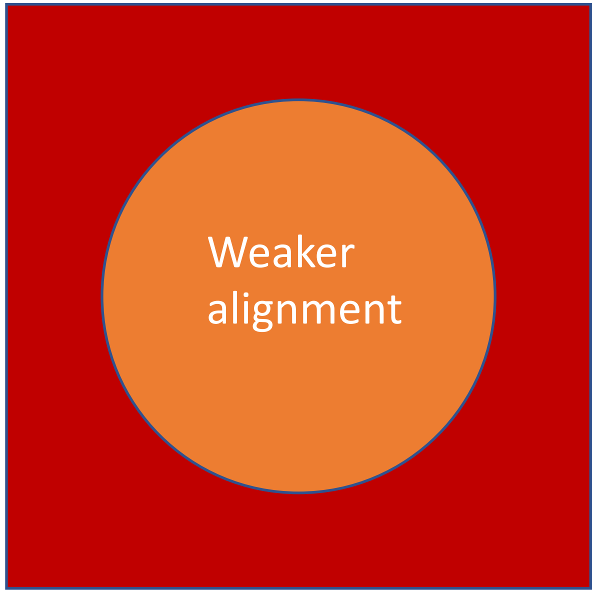




Walls, repulsive sites, attractive sites...







Wall

Stronger

- Light
- Field
- Anchoring

Repulsive site

Stronger

- Light
- Field
- Anchoring

Attractive site

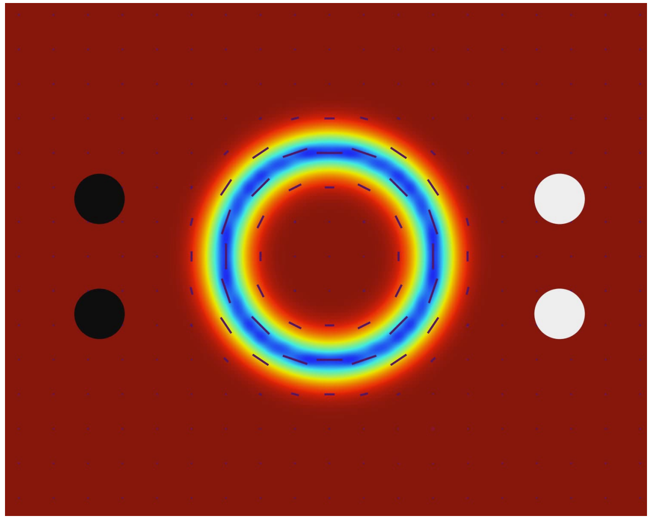
Weaker

- Light
- Field
- Anchoring

Some ways to generate repulsive and attractive regions

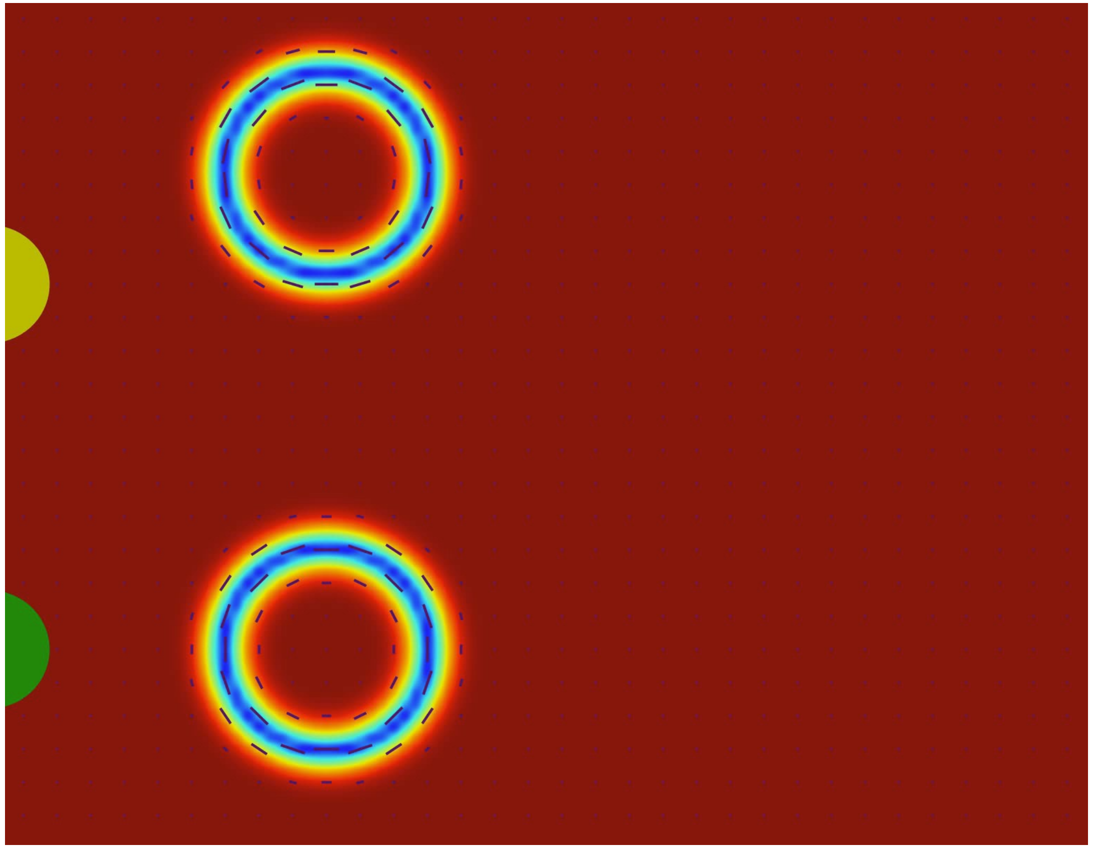
Strong Anchoring

Weak Anchoring

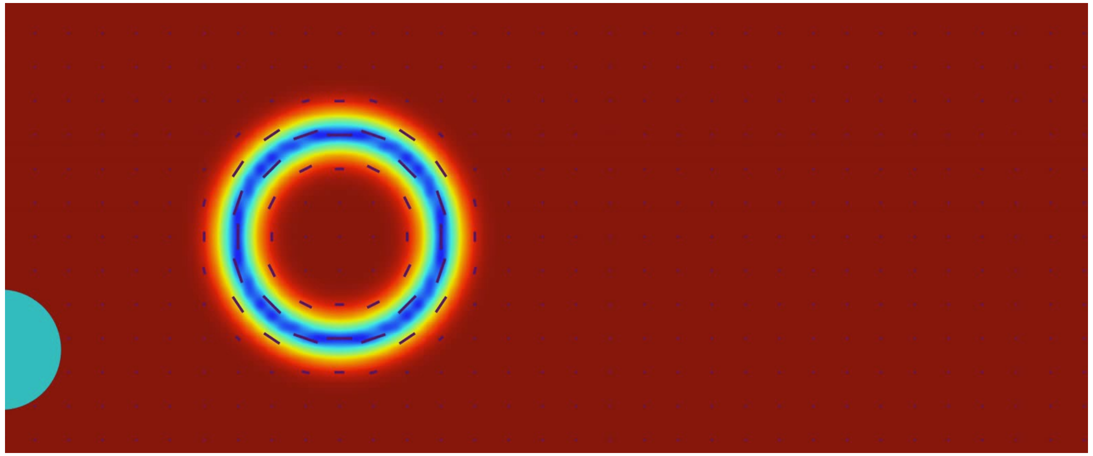


Cancelling Field

Strong Extra Field

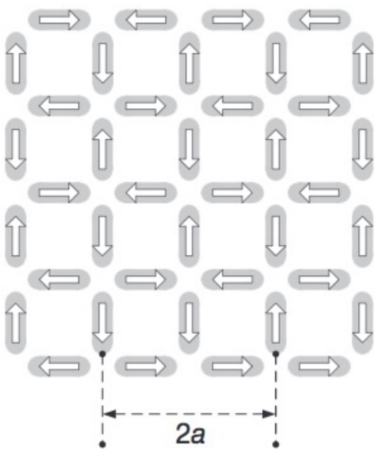


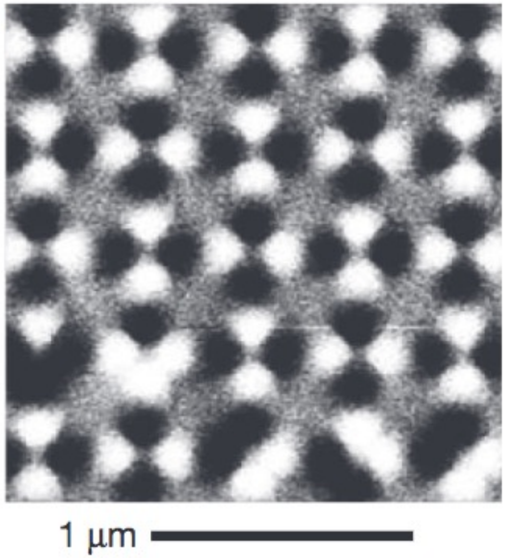
Light



Binary traps for skyrmions

ARTIFICIAL SPIN ICE





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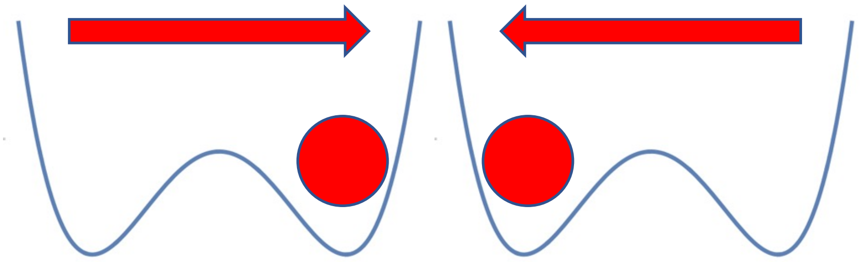
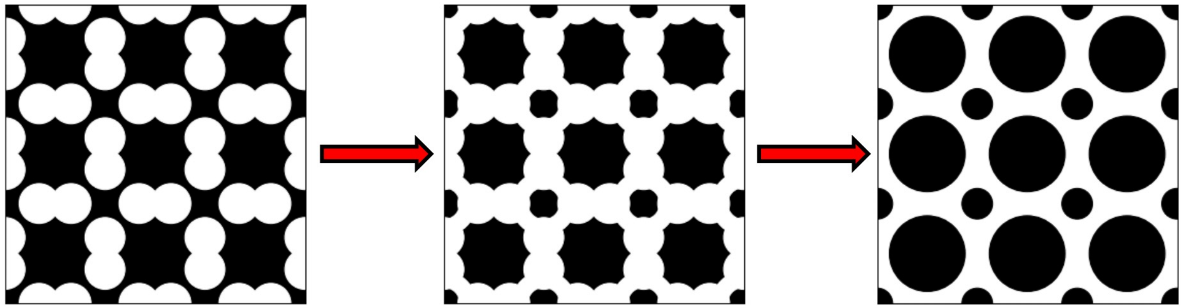
PARTICLE ICE

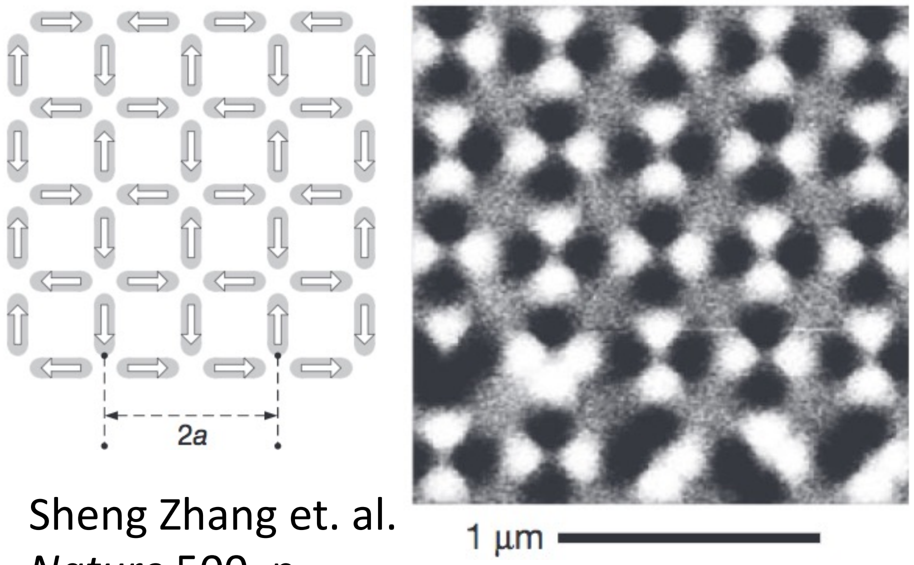


TRAP DESIGN



Binary traps for skyrmions

ARTIFICIAL SPIN ICE



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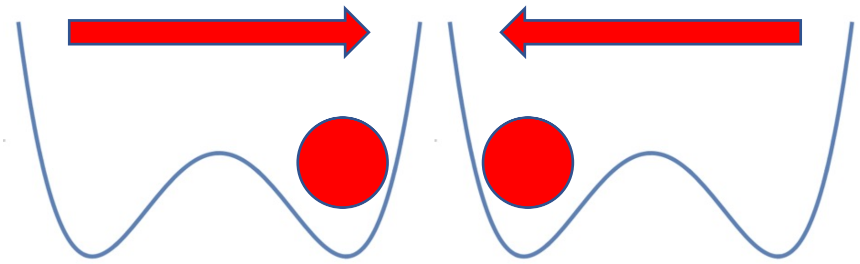

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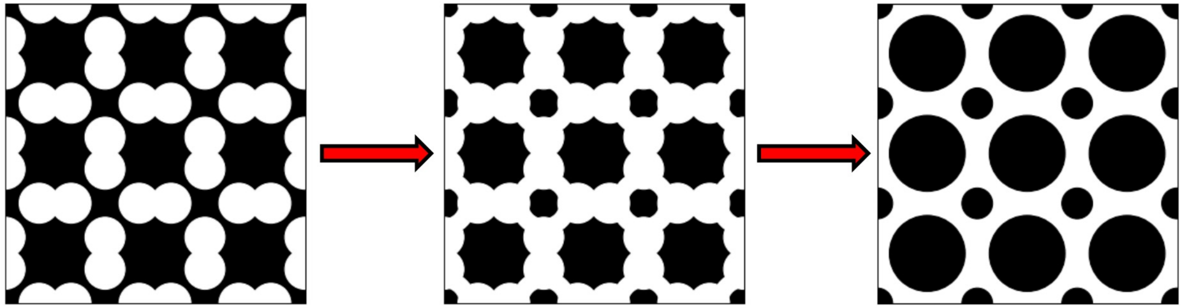
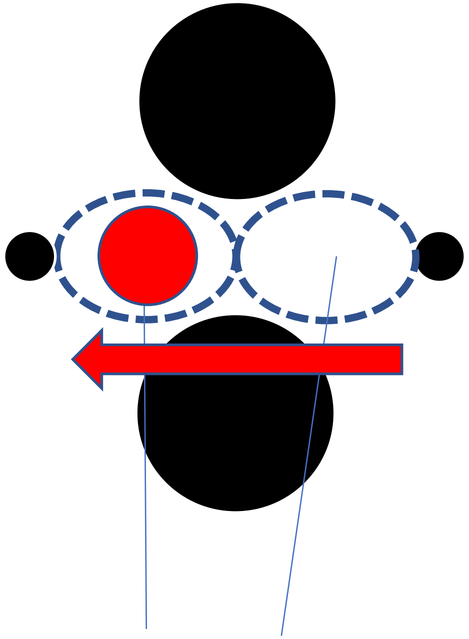
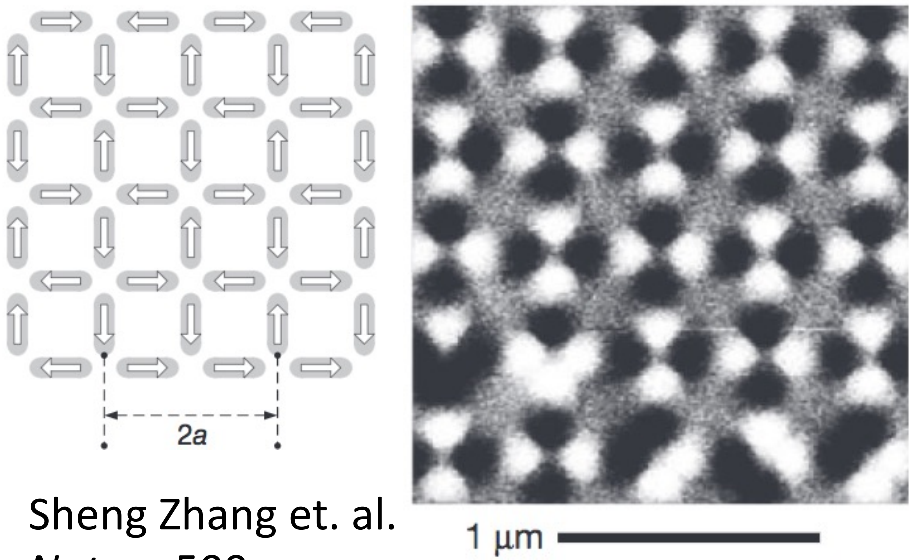




Binary traps for skyrmions

ARTIFICIAL SPIN ICE



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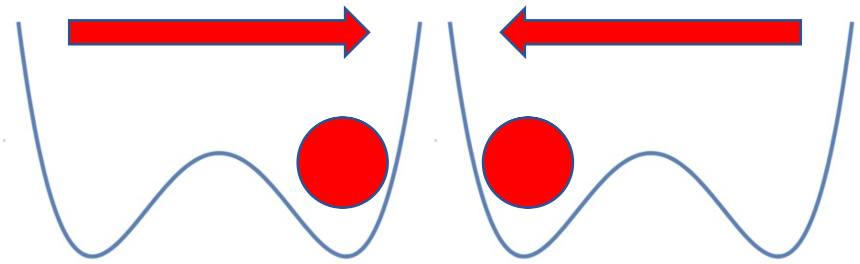
PARTICLE ICE



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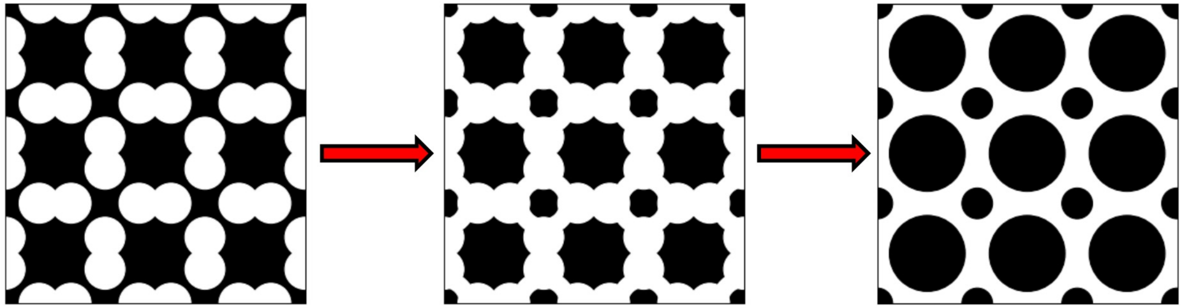
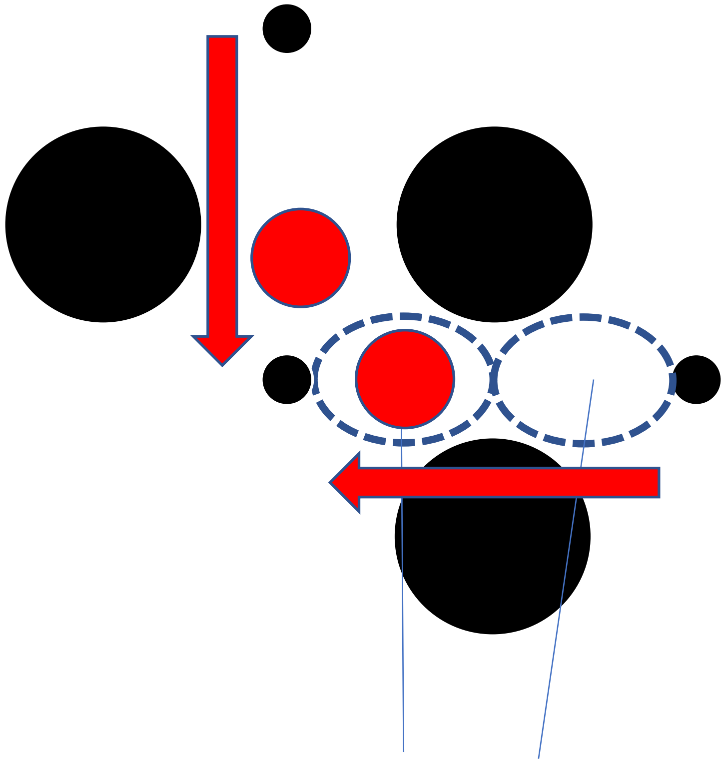
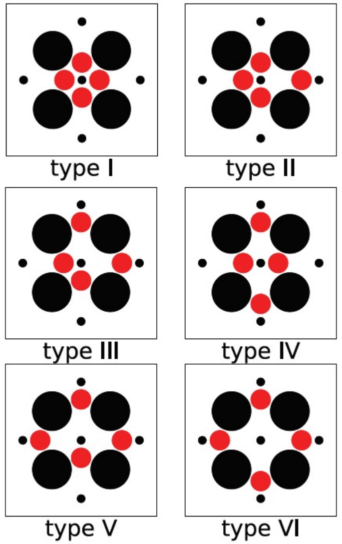
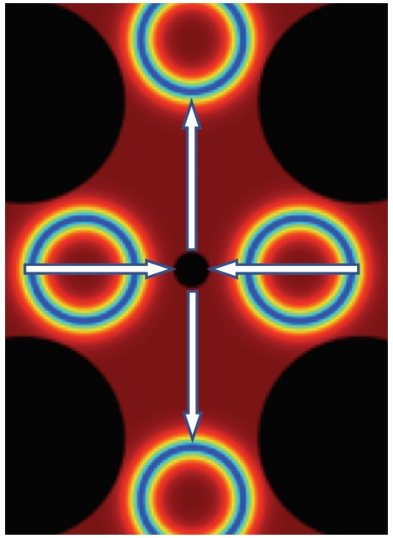


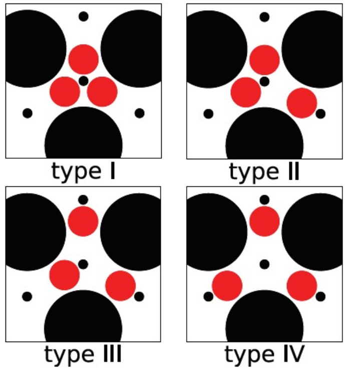


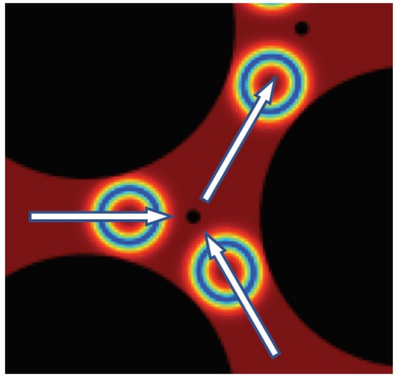
Ice rule



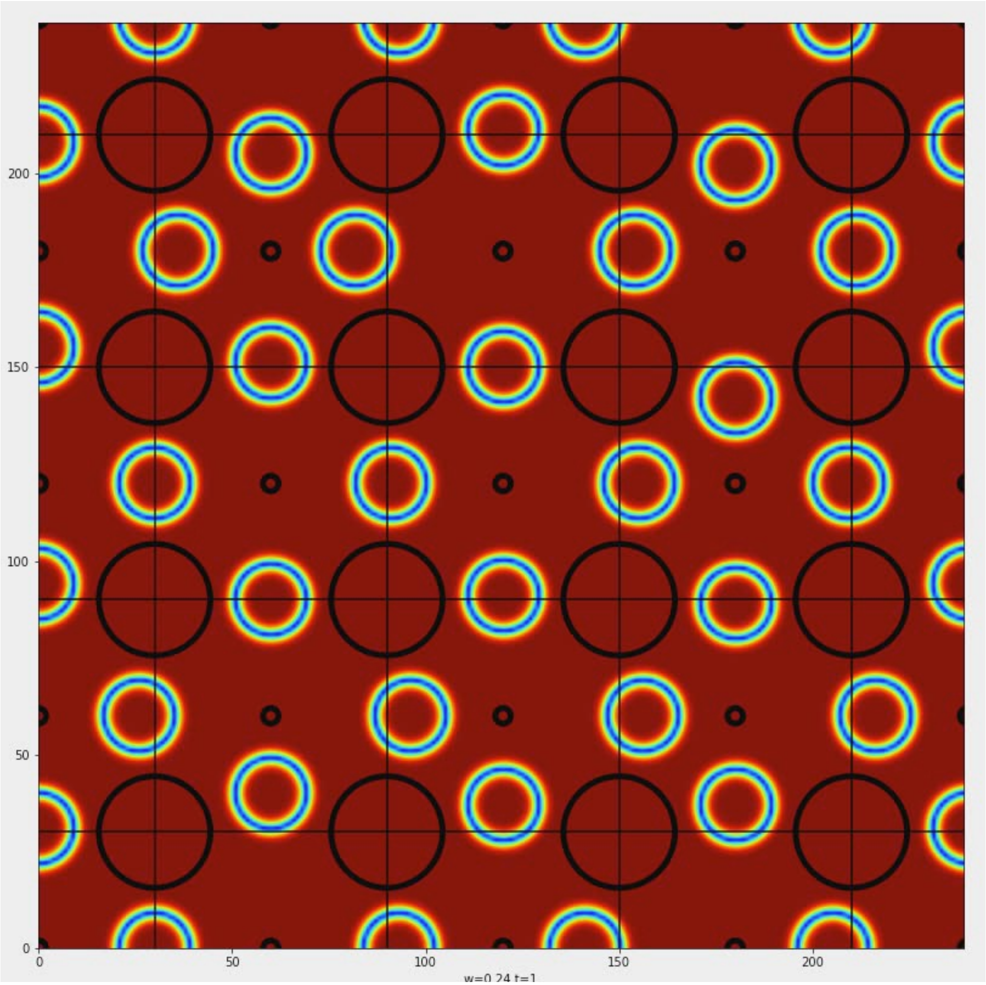


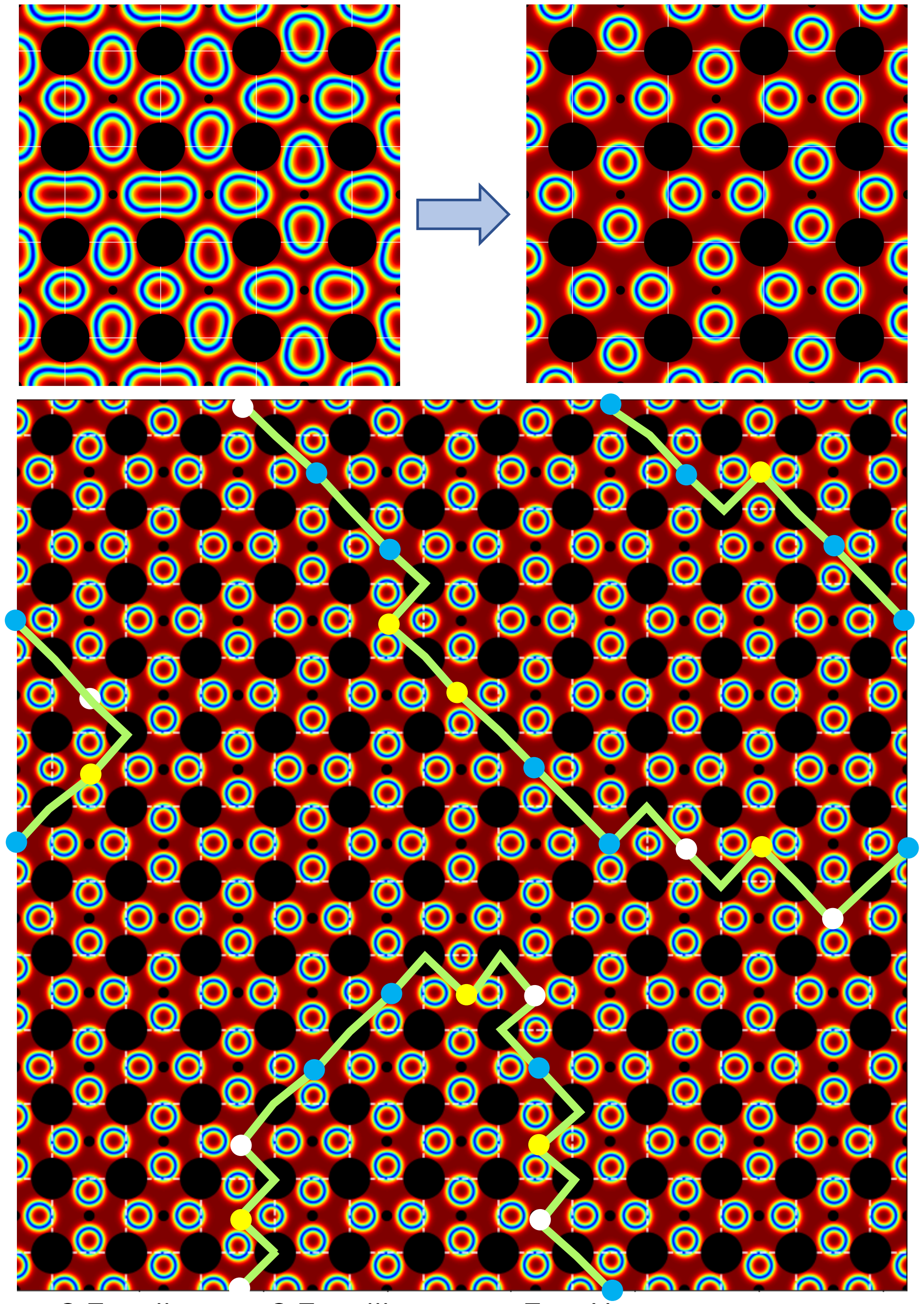
2 in-2 out



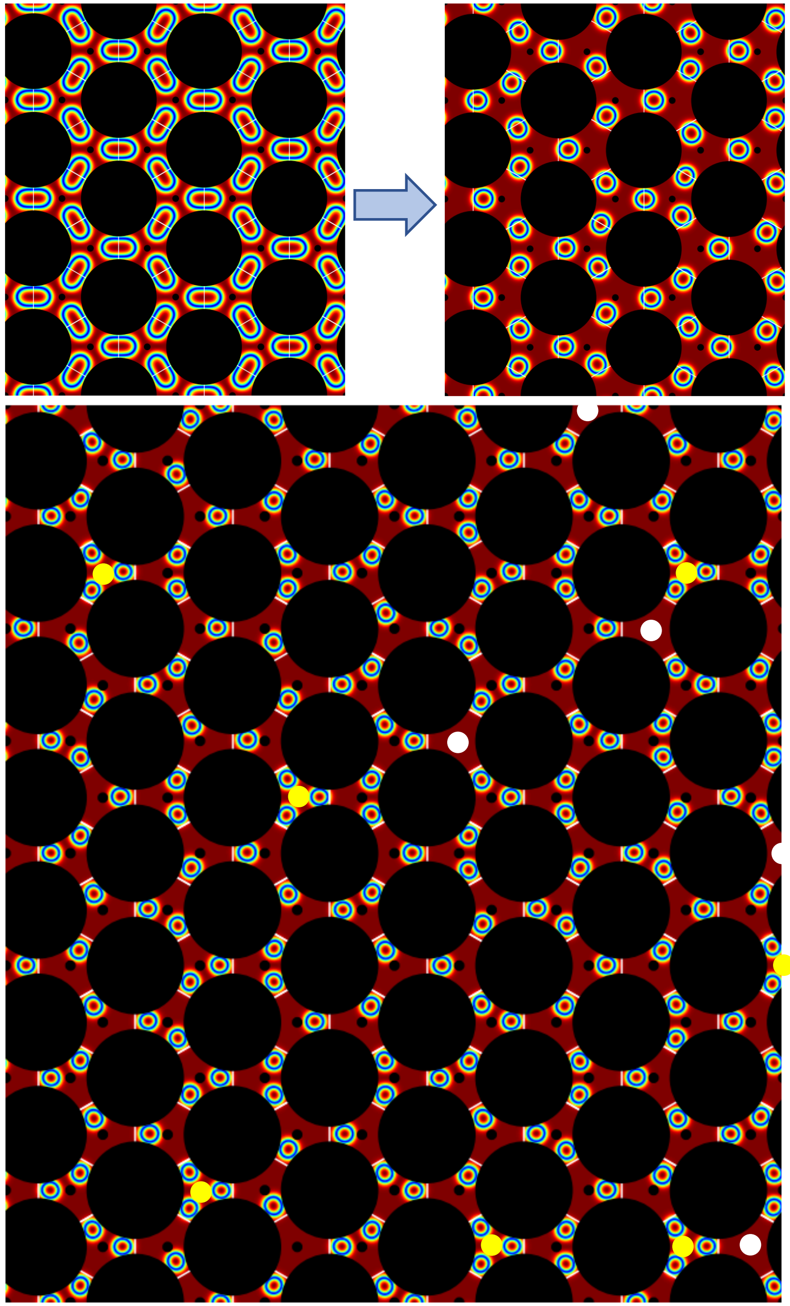


2 in-1 out
1 in-2 out





Type II Type III Type V



Type I Type IV

Validity range